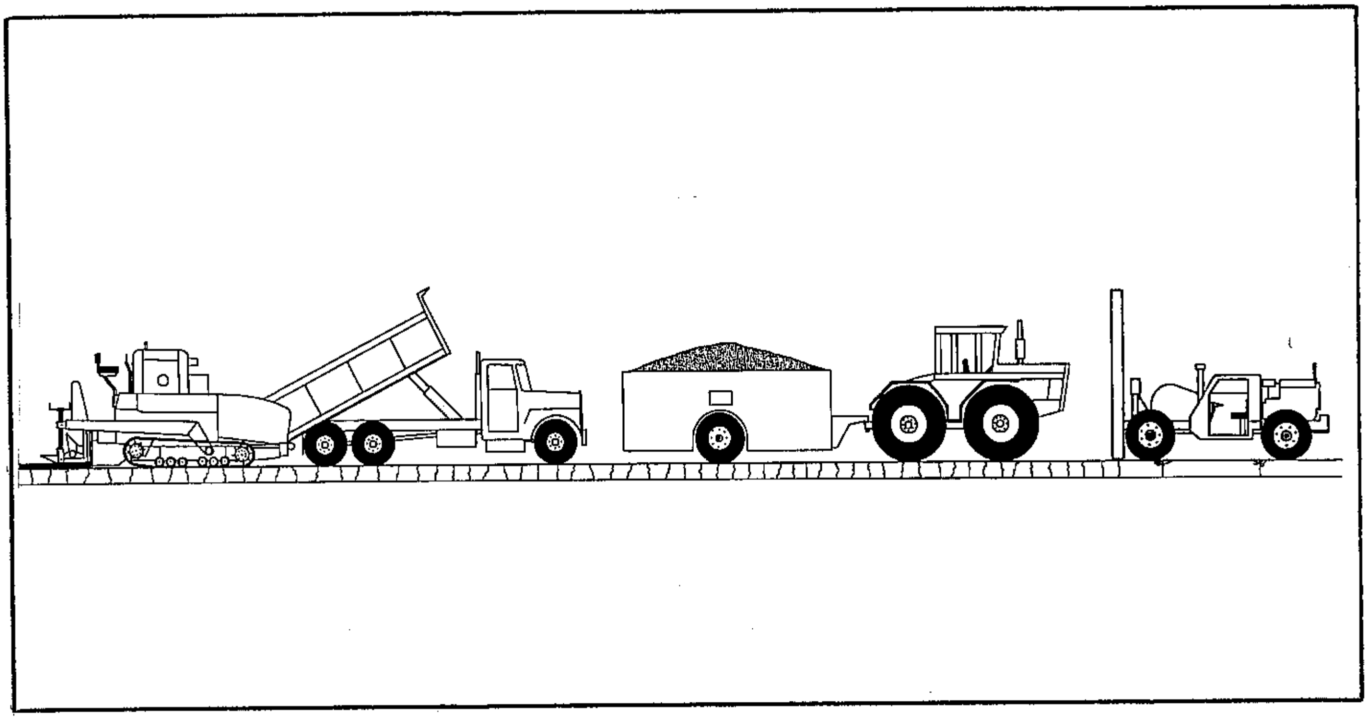

The Crack and Seat Method of Pavement Rehabilitation

Final Report

PHYSICAL RESEARCH REPORT NO. 104 / JULY 1988

Illinois Department of Transportation
Bureau of Materials and Physical Research

FINAL REPORT

IHR-515

THE CRACK AND SEAT METHOD OF PAVEMENT REHABILITATION

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16. Abstract

This paper describes a research project which evaluated the effectiveness of the crack and seat method of pavement rehabilitation. The process involved cracking a portland cement concrete pavement into 1 1/2 - 2-foot size pieces and firmly seating the pieces into the subgrade prior to overlaying with asphalt concrete. Cracking the pavement serves to reduce the concrete slab's horizontal movement due to thermal expansion and contraction. Seating the cracked pieces minimizes vertical movement in the slab by restoring subgrade support. Minimizing movement in the underlying concrete pavement should theoretically reduce the stresses in the asphalt concrete overlay that result in reflective cracking. While not guaranteed to eliminate reflective cracking, cracking and seating is designed to reduce or retard reflective cracking.

Six construction sections located throughout the State of Illinois were cracked and seated between 1983 and 1987. Originally constructed in the 1920's and 1930's, the majority of the pavements were of the thickened edge design and contained longitudinal edge bars for reinforcement. One pavement did contain reinforcing mesh. The pavements were cracked with either a hydraulic powered or a guillotine hammer. A test section was established where the breaker drop height and spacing was varied. The desired crack pattern consisted of hairline cracks capable of maintaining aggregate interlock. A fine spray of water was sometimes applied to verify cracking. On those pavements with existing asphalt overlays, portions of the overlay were removed to verify that the underlying concrete slab was being cracked. Pavements were then seated with either a 35-ton or a 50-ton rubber tire roller. Soft areas were patched full-depth with asphalt concrete prior to overlaying. Overlay thicknesses ranged from 3 - 7 1/2 inches. Control sections, sections that were overlaid but not cracked and seated, were established on some of the jobs. However, overlay thicknesses in the control sections were not always comparable to overlay thicknesses over the cracked and seated sections. After construction, the projects were visually surveyed biannually.

The six sections have been in service between 1 and 5 years. The crack and seat process does seem to have been beneficial in reducing the amount of reflective cracking on the thickened edge pavements. Based on the findings, the crack and seat method of rehabilitation is not recommended for use on reinforced pavements. A sample specification incorporating the study's findings is included in the report.

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I. INTRODUCTION

The State of Illinois' primary system has many miles of jointed plain and reinforced portland cement concrete pavements in need of some form of rehabilitation. Resurfacing with asphalt concrete is the method of rehabilitation most commonly used in Illinois. In time, however, cracks reflect through the asphalt overlay directly over the joints and cracks in the concrete pavement.

Both horizontal and vertical movements in the underlying portland cement concrete pavement contribute to the reflective cracking in the asphalt concrete overlay. Horizontal movements are caused by the expansion and contraction of the slab in response to temperature variation. Traffic produces vertical movement at joints and cracks in the underlying pavement. These movements create stresses in the overlay that result in reflective cracking.

Maintaining overlays with reflective cracking can be a costly endeavor. Reducing or retarding reflective cracking can extend the service life of the overlay and ensure a more profitable return on the rehabilitation dollar. Cracking and seating portland cement concrete pavements prior to resurfacing is one method proposed to reduce or retard reflective cracking.

Cracking and seating seeks to minimize the movement in the underlying concrete pavement. Cracking the slab into small pieces reduces the horizontal movement due to thermal expansion and contraction. Seating the pavement minimizes vertical movement by restoring subgrade support. Minimizing movement in the underlying concrete pavement should, theoretically, reduce the amount of reflective cracking in the bituminous overlay.

The main objective of this study was to evaluate the effectiveness of the crack and seat method of pavement rehabilitation. The primary benefits of favorable crack and seat performance included the extension of life of resurfacing projects and the reduction of future maintenance costs. Six projects were constructed and monitored for the study. The subject pavements were observed prior to and during construction. The projects were visually inspected biannually after construction to monitor the occurrence and progression of reflective cracking. Since crack surveys were not performed prior to cracking and seating, it was not possible to determine the actual percentage of crack reflectance, only its occurrence and progression. In addition, deflection tests were run biannually after construction with a Falling Weight Deflectometer.

Control sections were defined as sections that were not cracked and seated, yet received an asphalt overlay. Those projects that had control sections were monitored in the same manner as the crack and seat sections. Unfortunately, not all the projects had control sections due to lack of input during the design stage. Among the jobs that contained control sections, the overlay thickness in the control section was not always the same as the overlay thickness in the crack and seat section. This problem led to some difficulties in accurately assessing the effectiveness of cracking and seating.

II. GENERAL INFORMATION

Six projects were evaluated for the study. Figure 1 shows the general location of the projects. The same basic steps were followed on all of the projects, with only minor changes in equipment and procedures.

Two types of equipment were used to crack the concrete pavements. Five of the six test sections were cracked using a hydraulic powered spring arm hammer that could be controlled in both the vertical and horizontal directions. Several blows of the spring arm hammer were required to crack the full-lane width of the pavement. The remaining test section was cracked with a guillotine hammer, which featured a 12,000 pound, guided free-falling drop weight. The 6-foot guillotine was capable of producing full-lane width transverse cracking. Neither breaker scattered debris, which made it possible to maintain traffic in the adjacent lane and open the pavement to traffic after rolling, sweeping, and patching.

The size of the cracked pieces ranged from 1 1/2 - 2 feet per side. These dimensions were chosen based on the experience of others (1, 2, 3). Hammer drop height and spacing were varied in a test section to produce the required crack dimensions. The desired crack pattern consisted of fine, hairline cracks thereby maintaining aggregate interlock. Since the cracks were so fine, water was sometimes sprayed on the pavement in the test section to highlight the crack pattern. On one job, cores were taken over cracks to ensure that the cracks ran the full depth of the concrete slab. On those pavements that had an asphalt concrete overlay in place, 50-foot full-lane width test strips were removed at various locations throughout the project. This was done to verify that full-depth cracking was occurring through the overlay. Pavement widening, where scheduled, was completed prior to cracking and seating. Care was taken to minimize damage to the bituminous widening during the breaking operation. Culverts were marked and breaking stopped at 2 feet on either side of the drainage facility to prevent possible structural damage.

The majority of pavements were seated with 2 - 3 passes of a 50-ton rubber tire roller. Roller passes were staggered to ensure full coverage of the pavement. Soft spots and areas of pumping evident after rolling were patched full-depth with asphalt concrete. Traffic was allowed on all the pavements prior to overlaying. The contractors were required to maintain the pavements for traffic by sweeping and patching. Care was taken, however, to ensure that the overlays were placed prior to winter.

Overlay thicknesses ranged from 3 - 7 1/2 inches. Some overlay thicknesses were basically cost comparisons: if a 2-inch overlay with typical patching quantities cost "X" dollars, what thickness of overlay could be placed over a cracked and seated pavement with minimal patching for the same "X" dollars. Other designs assigned a structural coefficient value of 0.28 to the cracked pavement -- a value near that of a cement stabilized aggregate base. During the latter stages of the project, the University of Illinois developed an overlay thickness design procedure in conjunction with IHR-510, Mechanistic Evaluation of Illinois Flexible Pavement Design Procedures. This design concept was applied on the sixth experimental section, Illinois Route 99.

III. PAVEMENT EVALUATION SECTIONS

Original pavement data and crack and seat information on the six sections is summarized in Table 1.

Lincoln Trail Road

Lincoln Trail Road is located in Fairview Heights, Illinois. This 2-lane residential street was cracked and seated in 1983. The 1.73-mile project featured 4,654 feet of cracked and seated pavement with a 4-inch asphalt overlay and 4,500 feet of control section that had a 2-inch asphalt overlay over the patched pavement. Total average daily traffic (ADT) for 1982 was 4,600.

Originally constructed 55 - 65 years ago, Lincoln Trail featured a 9 1/2 - 7 - 9 1/2 thickened edge design with 1-inch diameter edge bars. A 1 - 2-inch asphalt overlay placed in the mid 1950's was badly deteriorated. The overlay remained in place during the cracking operation, but soil adjacent to the pavement was removed at several locations to verify full-depth cracking. A spring arm hammer was used to crack the pavement. After seating the pavement with 2 - 3 passes of a 50-ton rubber tire roller, a few soft spots were discovered, marked and patched. Traffic was allowed on the pavement prior to placement of a 4-inch asphalt overlay. The pavement cross section is shown in Figure 2.

Illinois Route 97

Located between the Mason/Menard county line and the town of Atterberry, Illinois, this 4.9-mile stretch was cracked and seated in 1984. Approximately 4.1 miles received a 4-inch asphalt overlay, while the remaining 0.8 mile received a 3-inch overlay. In addition, two control sections were placed. A 3-inch overlay was placed over 0.4 mile of patched, non-cracked and seated pavement, and a 2-inch overlay was placed over 0.5 mile of patched, non-cracked and seated pavement. The 1985 total ADT was 1,850, with 100 multi-unit and 100 single-unit trucks.

The original pavement was constructed in 1939. It was a thickened edge pavement of 9 - 7 - 9 design with 50-foot joint spacing. This pavement differed from others in the study because it contained

55 pounds of reinforcing steel per 100 square feet of pavement. Route 97 was bare at the time of cracking and seating and virtually every joint and the majority of cracks were badly spalled and deteriorated. The cross section for Illinois Route 97 is shown in Figure 3. Cracking was accomplished with a spring arm hammer and rolling with a 50-ton rubber tire roller. The pavement was watered to check the crack pattern. Rolling produced no soft spots, and therefore no patching was required.

Illinois Route 101

The Illinois Route 101 section is located between the towns of Brooklyn and Littleton, Illinois. In 1984, 3.2 miles of the section between Illinois Route 99 and Littleton, Illinois was cracked, seated and covered with a 4.5-inch overlay. A 2-inch asphalt overlay control section was placed through the town of Brooklyn where the pavement was not cracked and seated. Total ADT for 1985 was 700 with approximately 20 multi-unit and 50 single-unit trucks.

Illinois Route 101 was built in 1929. It was a 9 - 6 - 9 thickened edge pavement with 3/4-inch diameter edge bars. A badly deteriorated 3-inch asphalt overlay put down in 1960 was left in place, but a number of test strips were removed to verify that full-depth cracking had occurred. Figure 4 details the cross section of Illinois Route 101. A spring arm hammer was used to crack the pavement and 2 passes of a 50-ton rubber tire roller were made to seat the pavement. Approximately 2% of the pavement required patching after rolling.

Rockton Road

Located in the far northern portion of the state, this 3.3-mile section west of the town of Rockton, Illinois was cracked and seated in 1984. Two overlay thicknesses were placed: 2.8 miles of 3-inch asphalt concrete, and 0.5 mile of 4-inch asphalt concrete. A geotextile fabric was placed over the leveling binder in the 4-inch section because the County Superintendent had reported a history of water problems. No control sections were constructed at this site. The 1981 total ADT for this section was 1,550 with 78 multi-unit and 108 single-unit trucks.

Originally constructed in 1932, Rockton Road was a 9 - 6 - 9 thickened edge pavement with 3/4-inch diameter edge bars. Joint spacing was 30 feet with every third joint an expansion joint and contraction joints between. The existing asphalt overlay was removed prior to cracking and seating, revealing badly deteriorated joints. The pavement cross section is detailed in Figure 5. This pavement was also cracked with a spring arm hammer and seated with three passes of a 50-ton rubber tire roller. No pumping or soft spots were observed.

U.S. Route 6

Located on the outskirts of Princeton, Illinois, this 1.2-mile section was cracked and seated in 1985. Approximately one-half of the project received a 3 1/2-inch asphalt overlay; the other one-half had a 4-inch asphalt overlay. A geotextile fabric was placed over the leveling binder on top of the widening joint on both sections as an additional reflective crack control treatment. No control sections were constructed at this site. The total ADT for 1985 was 3,300 with 75 multi-unit and 75 single-unit trucks.

Constructed in 1924, this pavement was a 9 - 6 - 9 thickened edge design with 3/4-inch diameter edge bars. The pavement was bare at the time of cracking and seating and was badly cracked and settled. The cross section for U. S. Route 6 is shown in Figure 6. The pavement was cracked with a spring arm hammer and seated with 1 - 2 passes of a 50-ton rubber tire roller. Soft spots were patched with asphalt concrete prior to overlaying.

Illinois Route 99

The sixth crack and seat project is located on Illinois Route 99 between the towns of Mt. Sterling and Versailles, Illinois. Approximately 3.2 miles were cracked and seated in 1987. Four overlay thicknesses were placed: 4 1/2, 5 1/2, 6 1/2 and 7 1/2 inches. A geotextile fabric was placed over the first lift of binder on top of the widening joint in the crack and seat sections as an additional reflective crack control treatment. There were also three control sections: 4 1/2, 5 1/2 and 6 1/2-inch overlays over non-cracked and seated pavement. The total ADT for 1985 was 1,985 with 238 multi-unit and 119 single-unit trucks.

The original pavement was constructed in 1933 and was a 9 - 6 - 9 thickened edge pavement with 3/4-inch diameter edge bars. The pavement had been overlaid in 1970 with 3 inches of asphalt concrete. The cross section is shown in Figure 7. Heavy coal truck traffic had caused serious damage to the pavement. The overlay remained in place, but portions were removed to verify full-depth cracking. Unlike the other sections, this pavement was cracked with a guillotine hammer. The pavement was watered to check the crack pattern. Two passes were made with a 35-ton rubber tire roller to seat the pavement. Rolling produced three soft spots in the 3.2-mile section. The soft areas were removed and patched with asphalt concrete before overlaying.

The Illinois Route 99 section was the result of the learning curve developed on the other five projects. Four overlay thicknesses were tested and three control sections established. Surveys were made prior to construction so that the degree of reflective cracking could be monitored. In addition, this section received the highest level of truck traffic of all the experimental sections. These factors combined to make Illinois Route 99 the most comprehensive test of the cracking and seating process in Illinois.

The overlay design procedure used on Illinois Route 99 was also the product of several years of work. The procedure was developed by Professor Marshall Thompson of the University of Illinois in conjunction with IHR-510, Mechanistic Evaluation of Illinois Flexible Pavement Design Procedures. Design inputs were the resilient subgrade modulus (E_{Ri}), asphalt concrete modulus (E_{AC}), and the "equivalent modulus" of the cracked and seated concrete (E_{CS}). The asphalt concrete bending strain was used to determine the required overlay thickness based on fatigue in the asphalt concrete layer.

IV. PERFORMANCE OF SECTIONS

The six projects evaluated in this study have been monitored for one to five years. It was difficult to determine just what benefits were directly attributable to the cracking and seating process due to a lack of adequate control sections. However, such variables as transverse crack spacing, lineal feet of longitudinal cracking, and lineal feet of widening cracking proved informative. Transverse crack spacing was defined as follows:

$$S = \frac{L_S}{L_T/W}$$

Where: S = Transverse Crack Spacing, Feet

L_S = Length of Survey Section, Feet

L_T = Cumulative Total Length of Transverse Cracks, Feet

W = Pavement Width, Feet

Tables 2 - 7 and Figures 8, 13-15, and 18 detail the progression of cracking observed throughout the study.

Lincoln Trail Road

After five years in service, the crack and seat section seems to be performing well. While not directly comparable to the control section due to differences in overlay thickness, cracking and seating did significantly reduce the amount of transverse cracking, as can be seen in Table 2 and Figure 8. There was a slight increase in the amount of longitudinal cracking shown in Figure 9, which may be attributable to the type of pavement breaker used and the crack pattern it produced. Other states have noted that continuous longitudinal cracking should be avoided due to its tendency to reflect through the overlay (2). Prior to the last survey, all the cracks had been routed and sealed.

Illinois Route 97

At first glance, Illinois Route 97 seems to be the poorest performing section. After four years in service, transverse and longitudinal cracking are present in both the crack and seat and control sections, as can be seen in Figures 10-12. However, Table 3 and Figure 13 do show that there is less transverse and widening cracking present in the crack and seat sections than in the control sections. The majority of patches are reflecting through the overlay in the control sections, as shown in Figure 10. While there is more longitudinal midlane cracking in the crack and seat section, it appears to be a result of mix segregation in the paver auger during laydown.

Illinois Route 101

Illinois Route 101, constructed at the same time as Illinois Route 97, is in excellent condition. The crack and seat section with a 4.5-inch overlay shows only 4 feet of transverse cracking in the 1,000-foot test section, for a transverse crack spacing of 5,550 feet. The control section, with a conventional 2-inch overlay, has a transverse crack spacing of 60 feet. While the two sections are not directly comparable due to differences in overlay thicknesses, it is evident that the crack and seat section is performing as was expected. Table 4 and Figure 14 detail the progression of reflective cracking.

Rockton Road

Table 5 and Figure 15 contain reflected crack survey data from Rockton Road. As expected, the 4-inch overlay outperformed the 3-inch overlay, at least in terms of transverse crack spacing. It appears that on this project, an additional 1-inch of thickness bought 1 1/2 years of reflective crack prevention. This is based on the observation that a transverse crack spacing of 115 feet was noted in May 1988 in the 4-inch overlay section, while a transverse crack spacing of 110 feet was recorded in November 1986 in the 3-inch overlay section. However, such a simplistic comparison overlooks the fact that the 4-inch overlay section had a history of water problems and frost-susceptible soils. These conditions may also explain the increased longitudinal cracking found in the 4-inch overlay section, as shown in Figure 16.

U.S. Route 6

Two years after construction, both the 3 1/2-inch and the 4-inch overlays were in excellent condition. After the third year in service, both sections had an increase in transverse cracking and the 3 1/2-inch overlay experienced a large increase in longitudinal and widening cracking. Table 6 and Figure 18 illustrate this. To some extent the increase in cracking can be attributed to segregation in the asphalt concrete overlay mixture, as can be seen in Figure 17. The open texture of the mix allows water infiltration and promotes crack formation.

Illinois Route 99

After one year in service, all of the crack and seat and control sections are in excellent condition with no signs of reflective cracking. Table 7 has the crack survey data for Illinois Route 99.

V. DISCUSSION

Two factors prevent any firm conclusions from being drawn about the ability of cracking and seating to reduce reflective cracking: lack of traffic and lack of control sections. With the exception of Illinois Route 99, none of the pavements receive in excess of 100 multi-units a day.

Illinois Route 99, with 238 multi-unit and 119 single-unit trucks per day, provides a greater number of 18 kip eouivalent single axle loads (ESAL's) and provides a more realistic test of the ability of cracking and seating to reduce reflective cracking. More importantly, it is difficult to assess the performance of the crack and seat sections in Illinois given the lack of comparable control sections. Again, Illinois Route 99 is the only project with true control sections. For these reasons, it is impossible to draw final conclusions on the performance of cracking and seating at this time. The Illinois Route 99 project will continue to be monitored and valuable information gathered. A more informed decision on the effectiveness of cracking and seating can best be made after this section has been in service for 5 - 10 years.

Due to the lack of comparable control sections, it is difficult to tell what benefits were derived from the cracking and seating process and which are attributable to the increased overlay thickness. Aside from Illinois Route 99, only Illinois Route 97 features a control section with an overlay thickness equal to the overlay thickness on a cracked and seated section. While the crack and seat sections on Illinois Route 97 are performing poorly, they are still in better condition than the control sections. Table 3 indicates that the transverse crack spacing in the crack and seat section with a 3-inch overlay is approximately double the transverse crack spacing in the conventional section with a 3-inch overlay. Also of interest is the observation that the June 1987 transverse crack spacing in the crack and seat section with a 3-inch overlay is 35 feet. This value is comparable to the 36-foot transverse crack spacing found in the conventional section with a 3-inch overlay a few months after construction. On this section at least, it appears that cracking and seating delayed the degree of reflective cracking for approximately three years.

This raises the question of whether cracking and seating is a cost-effective method of rehabilitation. Cracking and seating costs for the six projects are shown in Table 8. Costs varied but appeared to be related to contractor experience. Of the three jobs located in close proximity, Illinois Routes 97, 101, and 99, costs fell as the contractors became more familiar with the procedure. If cracking and seating with a 3-inch overlay did indeed retard the degree of reflective cracking for three years on Illinois Route 97, then the average annual cost for the rehabilitation amounted to less than $0.19 per square yard.

While it has been pointed out that Illinois Route 97 is the poorest performing section, it must also be remembered that it was the only pavement in the study that contained reinforcing steel. Falling Weight Deflectometer tests done on the experimental sections after cracking, seating, and overlaying indicated an average concrete modulus of almost 3,000,000 psi on Illinois Route 97. Concrete moduli values from the other cracked and seated pavements averaged 546,000 psi. These values are listed in Table 9. Such a high modulus value on the Illinois Route 97 project would seem to indicate that the reinforcing steel was not adequately broken during the cracking process. The steel still held the concrete together and as it expanded and contracted in response to temperature variations, stresses developed in the overlay and resulted in reflective cracking. Other studies have confirmed that jointed reinforced pavements are not suited to cracking and seating (4).

Information provided by Professor Marshall Thompson of the University of Illinois also indicated the importance of adequately breaking the concrete. Willard Airport Road in Savoy, Illinois is under the jurisdiction of the University of Illinois. This 7-inch plain portland cement concrete pavement was cracked and seated in 1984. The pavement was cracked with a spring arm hammer on a very hot day and overlaid with 4 inches of asphalt concrete. Reflective cracking appeared very early. Falling Weight Deflectometer tests performed after cracking, seating, and overlaying indicated an average concrete modulus of 4,050,000 psi--a value similar to that of unbroken concrete. This test data is found in Table 9. The extremely hot conditions put the concrete in compression and apparently the spring arm hammer was not able to crack the pavement. Both Illinois Route 97 and the University of Illinois' Willard Airport Road point out the importance of establishing a test section where the cracking pattern can be varied and full-depth cracking verified by coring.

Both pavements exhibiting early reflective cracking due to insufficient slab cracking were broken with a hydraulic powered spring arm hammer. Coring and Falling Weight Deflectometer testing on the Illinois Route 99 section, which was cracked with a guillotine hammer, verified full-depth cracking. Based on the results of the FWD testing and the surveys showing early reflective cracking, it appears that a guillotine type hammer is best suited to provide the desired full-width, full-depth cracking pattern.

The seating process is equally important as the cracked pieces must be firmly seated on the subgrade or they will rock and produce reflective cracking. While adequate seating was obtained with both the 35-ton and 50-ton rubber tire rollers, current practice favors the 35-ton roller, especially on sections with weak subgrades (4). Steel wheel rollers and vibratory rollers are not recommended because they bridge over the pieces and do not adequately seat them.

VI. RECOMMENDATIONS

Based upon the observations made on the six experimental sections, the following recommendations are offered:

- A 100-foot test section should be designated on each job. The drop height and spacing of the pavement breaker can be varied to obtain the desired crack pattern. Cores should be taken over a crack to verify that full-depth cracking is taking place.

- A light spray of water should be applied to the test section after cracking to highlight the crack pattern.

- Certain precautions must be taken when cracking through an existing asphalt overlay. Asphalt concrete overlay test strips should be removed in 50-foot lengths to verify that the underlying concrete pavement is being cracked. These test strips should be located along the entire length of the job as pavement condition and overlay thickness may vary, and thus cause the crack pattern to vary.

- Guillotine type hammers or heavy guided, free-falling drop weights capable of producing full-lane width cracking, are recommended for the cracking process.

- Traffic can safely be maintained adjacent to the pavement breaker. Traffic can also be allowed on the cracked pavement prior to seating, and on the cracked and seated pavement prior to overlaying, provided that the pavement is patched and swept as needed. The cracked pavement should be rolled prior to overlaying if it has been open to traffic for a long period of time. Care should be taken however, to ensure that the cracked pavement is overlaid prior to winter.

- Adequate seating of the cracked pieces onto the subgrade can be achieved with a 35-ton rubber tire roller. One to five one-way passes per lane will be sufficient. The passes should overlap to ensure full-lane coverage.

- Use of the crack and seat process on reinforced concrete pavements is not recommended at this time. Thickened edge pavements containing edge bars are suitable for cracking and seating prior to overlaying.

- Overlay thicknesses should be carefully designed on the basis of traffic, subgrade support, and asphalt concrete and cracked and seated concrete moduli values. Overlay thickness designs should be reviewed by the Bureaus of Design and Materials and Physical Research until such time as mechanistic overlay designs for cracked and seated pavements are available for statewide implementation.

A sample specification incorporating these recommendations is included in Appendix A.

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The contents of this paper reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Illinois Department of Transportation nor the Federal Highway Administration. This paper does not constitute a standard, specification, or regulation.

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	LINCOLN TRAIL	ILLINOIS ROUTE 97	ILLINOIS ROUTE 101
YEAR CRACKED AND SEATED	1983	1984	1984
SECTION LENGTH	4,654'	25,900'	17,467'
BREAKING EQUIPMENT	SPRING ARM HAMMER	SPRING ARM HAMMER	SPRING ARM HAMMER
SIZE OF CRACKED PIECES	1.5'-2.0'/SIDE	1.5'-2.0'/SIDE	1.5'-2.0'/SIDE
ROLLER	50 TON RUBBER TIRE	50 TON RUBBER TIRE	50 TON RUBBER TIRE
OVERLAY THICKNESS	4"	3", 4"	4 1/2"
CONTROL SECTION	2" OVERLAY	2", 3" OVERLAYS	2" OVERLAY
TRAFFIC (ADT)	4,600 (1982)	1,850 WITH 100 MU'S AND 100 SU'S (1985)	700 WITH 20 MU'S AND 100 SU'S (1985)
<u>ORIGINAL PAVEMENT DATA</u>			
YEAR CONSTRUCTED	1920'S	1939	1929
SLAB THICKNESS	9 1/2"-7"-9 1/2"	9"-7"-9"	9"-6"-9"
REINFORCING	1" O EDGE BARS	55 LB. STEEL MESH/100 FT.^{2}	3/4" O EDGE BARS
JOINT SPACING	CONSTRUCTION JOINTS	50'	CONSTRUCTION JOINTS
PREVIOUS OVERLAY	1"-2" (1950'S)	NONE	3" (1960)
CONDITION	BADLY DETERIORATED	POOR-JOINTS AND CRACKS DETERIORATED	POOR-OVERLAY DETERIORATED

TABLE 1: CRACK AND SEAT SUMMARY INFORMATION

	ROCKTON ROAD	U. S. ROUTE 6	ILLINOIS ROUTE 99
YEAR CRACKED AND SEATED	1984	1985	1987
SECTION LENGTH	17,524'	6,150'	16,832'
BREAKING EQUIPMENT	SPRING ARM HAMMER	SPRING ARM HAMMER	GUILLOTINE
SIZE OF CRACKED PIECES	1.5'-2.0'/SIDE	1.5'-2.0'/SIDE	1.5'-2.0'/SIDE
ROLLER	50 TON RUBBER TIRE	50 TON RUBBER TIRE	35 TON RUBBER TIRE
OVERLAY THICKNESS	3" 4"	3 1/2", 4"	4 1/2", 5 1/2", 6 1/2", 7 1/2"
CONTROL SECTION	NONE	NONE	4 1/2", 5 1/2", 6 1/2" OVERLAYS
TRAFFIC (ADT)	1,550 with 78 MU'S AND 108 SU'S (1981)	3,300 WITH 75 MU'S AND 75 SU'S (1985)	1,985 WITH 238 MU'S AND 119 SU'S (1985)
ORIGINAL PAVEMENT DATA			
YEAR CONSTRUCTED	1932	1924	1933
SLAB THICKNESS	9"-6"-9"	9"-6"-9"	9"-6"-9"
REINFORCING	3/4" O EDGE BARS	3/4" O EDGE BARS	3/4" O EDGE BARS
JOINT SPACING	30' CONTRACTION, 90' EXPANSION	CONSTRUCTION JOINTS	
PREVIOUS OVERLAY	YES - WAS REMOVED	NONE	3" (1970)
CONDITION	VERY POOR - JOINTS DETERIORATED	CRACKING AND SETTLING	BADLY DETERIORATED

TABLE 1: CRACK AND SEAT SUMMARY INFORMATION (CONTINUED)

OVERLAY	SURVEY DATE	TRANSVERSE CRACK SPACING, FT.	LONGITUDINAL CRACKING, CUMULATIVE LIN. FT.	WIDENING CRACKING, CUMULATIVE LIN. FT.
CRACK AND SEAT	3/85	3025	6	---
WITH 4 INCHES	12/85	2420	6	---
(1100 FT. SECTION)	6/86	1424	6	---
	3/87	896	8	12
	9/87	896	8	20
	4/88	440	54	56
CONVENTIONAL	3/85	196	---	---
WITH 2 INCHES	12/85	104	---	---
(500 FT. SECTION)	6/86	92	11	---
	3/87	74	11	---
	9/87	73	13	---
	4/88	65	13	---

--- DENOTES NONE OBSERVED

TABLE 2: LINCOLN TRAIL ROAD - REFLECTED CRACK SURVEY DATA

OVERLAY	SURVEY DATE	TRANSVERSE CRACK SPACING, FT.	LONGITUDINAL CRACKING, CUMULATIVE LIN. FT.	WIDENING CRACKING, CUMULATIVE LIN. FT.
CONVENTIONAL	12/84	36	---	85
WITH 3 INCHES	6/85	25	---	98
(400 FT. SECTION, 12 FT. LANES)	12/85	21	---	150
	8/86	20	---	244
	12/86	19	---	279
	6/87	18	---	304
	4/88	17	---	316
CONVENTIONAL	12/84	54	---	21
WITH 2 INCHES	6/85	36	3	25
(600 FT. SECTION, 12 FT. LANES)	12/85	33	6	37
	8/86	28	66	64
	12/86	27	95	70
	6/87	26	117	78
	4/88	25	158	94
CRACK AND SEAT	12/84	889	---	---
WITH 4 INCHES	6/85	333	---	---
(1000 FT. SECTION, 12 FT. LANES)	12/85	238	---	---
	8/86	198	99	---
	12/86	137	357	---
	6/87	117	396	3
	4/88	77	564	3

TABLE 3: ILLINOIS ROUTE 97 - REFLECTED CRACK SURVEY DATA

OVERLAY	SURVEY DATE	TRANSVERSE CRACK SPACING, FT.	LONGITUDINAL CRACKING, CUMULATIVE LIN. FT.	WIDENING CRACKING, CUMULATIVE LIN. FT.
CRACK AND SEAT	12/84	267	---	---
WITH 3 INCHES	6/85	90	---	---
(1000 FT. SECTION, 12 FT. LANES)	12/85	56	---	4
	8/86	44	---	6
	12/86	38	4	31
	6/87	35	10	38
	4/88	30	107	82

--- DENOTES NONE OBSERVED

TABLE 3: ILLINOIS ROUTE 97 - REFLECTED CRACK SURVEY DATA (CONTINUED)

OVERLAY	SURVEY DATE	TRANSVERSE CRACK SPACING, FT.	LONGITUDINAL CRACKING, CUMULATIVE LIN. FT.	WIDENING CRACKING, CUMULATIVE LIN. FT.
CRACK AND SEAT	2/85	∞	---	---
WITH 4 1/2 INCHES	1/86	∞	---	---
(1000 FT. SECTION, 11 FT. LANES)	6/86	∞	---	---
	12/86	∞	---	---
	6/87	∞	---	---
	4/88	5500	---	---
CONVENTIONAL	2/85	310	---	28
WITH 2 INCHES	1/86	111	---	54
(1000 FT. SECTION, 11 FT. LANES)	6/86	86	---	54
	12/86	77	---	54
	6/87	74	---	54
	4/88	60	---	58

--- DENOTES NONE OBSERVED

TABLE 4: ILLINOIS ROUTE 101 - REFLECTED CRACK SURVEY DATA

OVERLAY	SURVEY DATE	TRANSVERSE CRACK SPACING, FT.	LONGITUDINAL CRACKING, CUMULATIVE LIN. FT.	WIDENING CRACKING, CUMULATIVE LIN. FT.
CRACK AND SEAT	6/86	558	179	---
WITH 4 INCHES	11/86	471	221	---
(1000 FT. SECTION, 12 FT. LANES)	7/87	381	274	2
	5/88	115	487	5
CRACK AND SEAT	6/86	157	59	---
WITH 3 INCHES	11/86	110	127	---
(1000 FT. SECTION, 12 FT. LANES)	7/87	90	150	---
	5/88	46	152	---

--- DENOTES NONE OBSERVED

TABLE 5: ROCKTON ROAD - REFLECTED CRACK SURVEY DATA

OVERLAY	SURVEY DATE	TRANSVERSE CRACK SPACING, FT.	LONGITUDINAL CRACKING, CUMULATIVE LIN. FT.	WIDENING CRACKING, CUMULATIVE LIN. FT.
CRACK AND SEAT	6/86	∞	---	---
WITH 4 INCHES	11/86	∞	4	---
(1000 FT. SECTION, 12 FT. LANES)	7/87	12,000	4	---
	5/88	212	20	4
CRACK AND SEAT	6/86	∞	---	---
WITH 3 1/2 INCHES	11/86	∞	5	---
(1000 FT. SECTION, 12 FT. LANES)	7/87	4,000	5	---
	5/88	144	255	79

--- DENOTES NONE OBSERVED

TABLE 6: U. S. ROUTE 6 - REFLECTED CRACK SURVEY DATA

OVERLAY	SURVEY DATE	TRANSVERSE CRACK SPACING, FT.	LONGITUDINAL CRACKING, CUMULATIVE LIN. FT.	WIDENING CRACKING, CUMULATIVE LIN. FT.
CRACK AND SEAT (1000 FT. SECTIONS, 12 FT. LANES)				
7 1/2 INCHES	4/88	∞	---	---
6 1/2 INCHES	4/88	∞	---	---
5 1/2 INCHES	4/88	∞	---	---
4 1/2 INCHES	4/88	∞	---	---
CONVENTIONAL (1000 FT. SECTIONS, 12 FT. LANES)				
6 1/2 INCHES	4/88	∞	---	---
5 1/2 INCHES	4/88	∞	---	---
4 1/2 INCHES	4/88	∞	---	---

--- DENOTES NONE OBSERVED

TABLE 7: ILLINOIS ROUTE 99 - REFLECTED CRACK SURVEY DATA

Project	Cost Per Square Yard
Lincoln Trail	$1.70
Illinois Route 97	$0.55
Illinois Route 101	$1.00
Rockton Road	$0.55
U.S. Route 6	$3.00
Illinois Route 99	$0.51

TABLE 8: CRACKING AND SEATING COSTS

PAVEMENT	TEST DATE	FALLING WEIGHT DEFLECTOMETER [1] 9,000 LB. LOAD DEFLECTION, MILS	CRACKED AND SEATED CONCRETE MODULI, [2] KSI
LINCOLN TRAIL	SUMMER/FALL 1985	7.8	1,080
LINCOLN TRAIL	SPRING 1986	8.4	770
ILLINOIS 97 - 3 IN.	SUMMER/FALL 1985	7.3	3,250
ILLINOIS 97 - 3 IN.	SPRING 1986	7.8	1,850
ILLINOIS 97 - 4 IN.	SUMMER/FALL 1985	8.7	4,000
ILLINOIS 97 - 4 IN.	SPRING 1986	7.3	2,400
ILLINOIS 101	SUMMER/FALL 1985	14.2	420
ILLINOIS 101	SPRING 1986	10.1	600
ROCKTON ROAD	SPRING 1985	14.0	150
ROCKTON ROAD	SPRING 1986	13.7	240
ROCKTON ROAD	SUMMER/FALL 1986	12.3	300
U. S. 6 - 3.5 IN.	SUMMER/FALL 1986	14.7	680
U. S. 6 - 4 IN.	SUMMER/FALL 1986	12.2	670
WILLARD AIRPORT RD.	SUMMER/FALL 1985	7.7	4,100
WILLARD AIRPORT RD.	SPRING 1986	5.3	4,000+

[1] Dynatest 8002 Falling Weight Deflectometer

[2] Cracked and seated concrete moduli back-calculated using the finite-element program ILLIPAVE.

TABLE 9: CRACKED AND SEATED CONCRETE MODULI VALUES

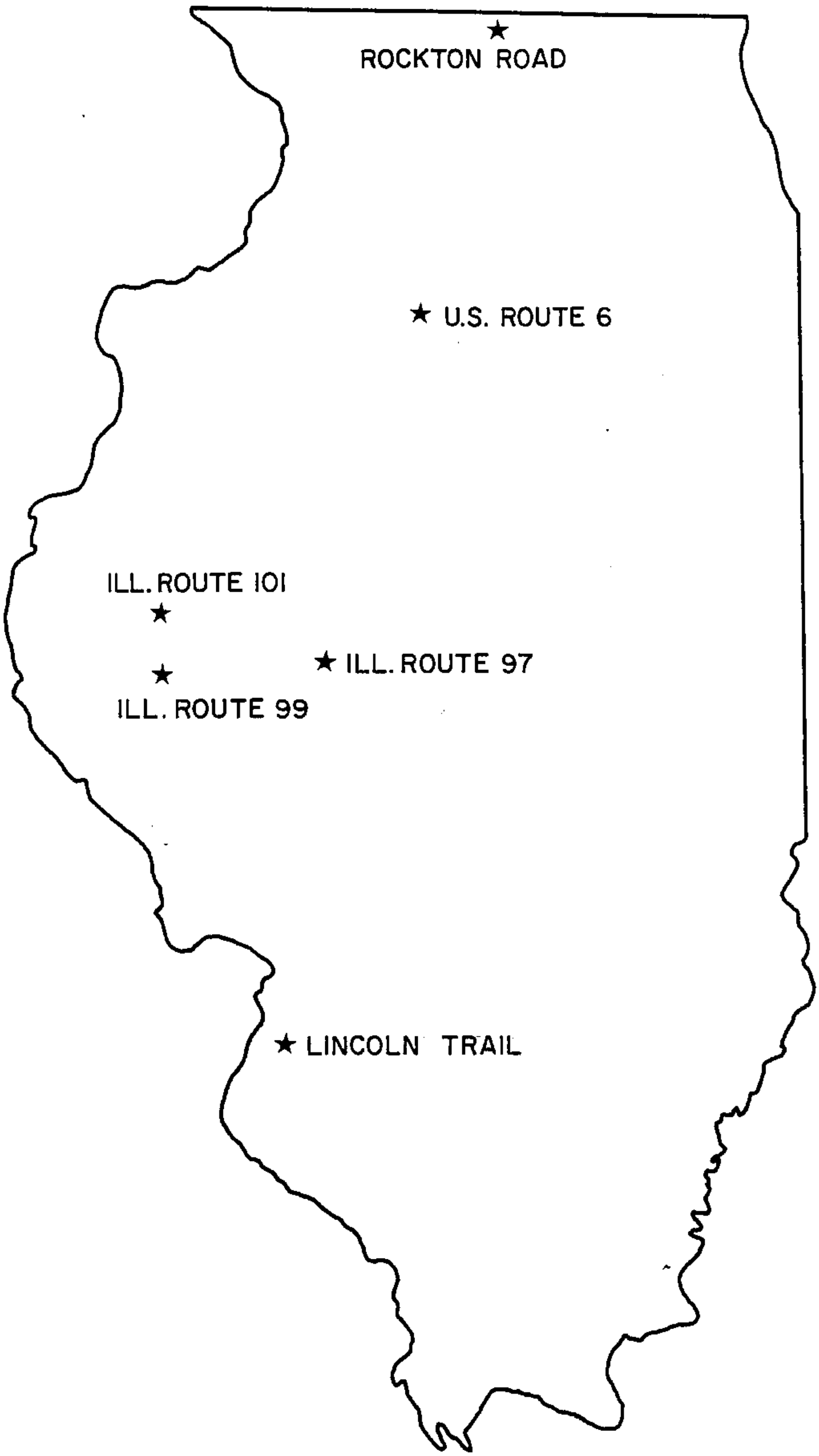
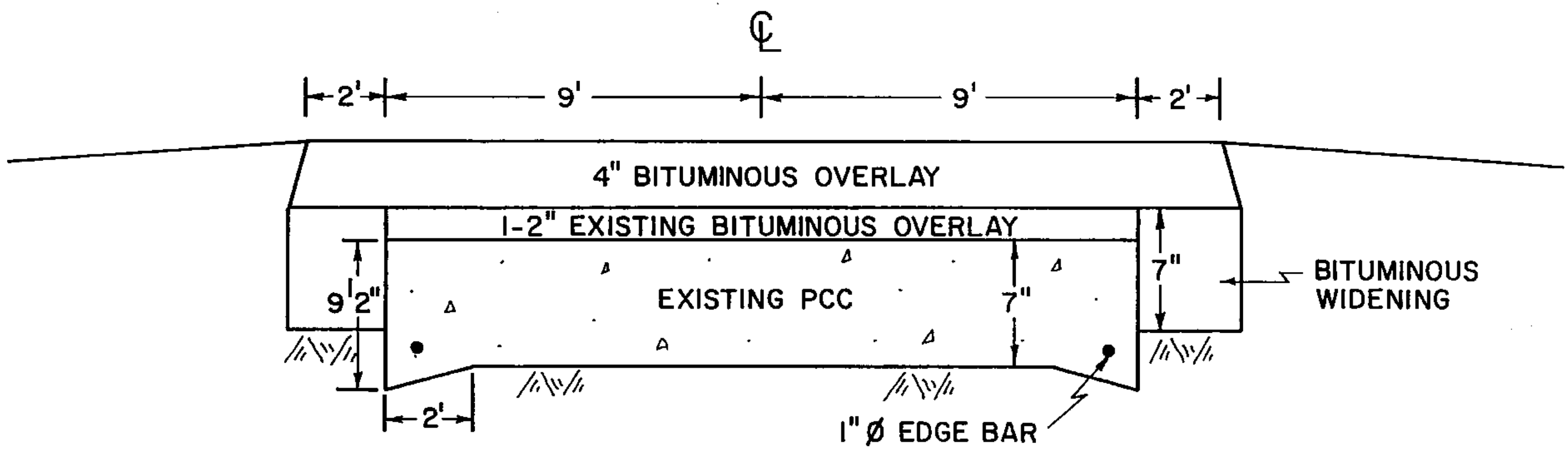


FIGURE 1: PROJECT LOCATION MAP



Not to scale

FIGURE 2: LINCOLN TRAIL CRACK AND SEAT CROSS SECTION

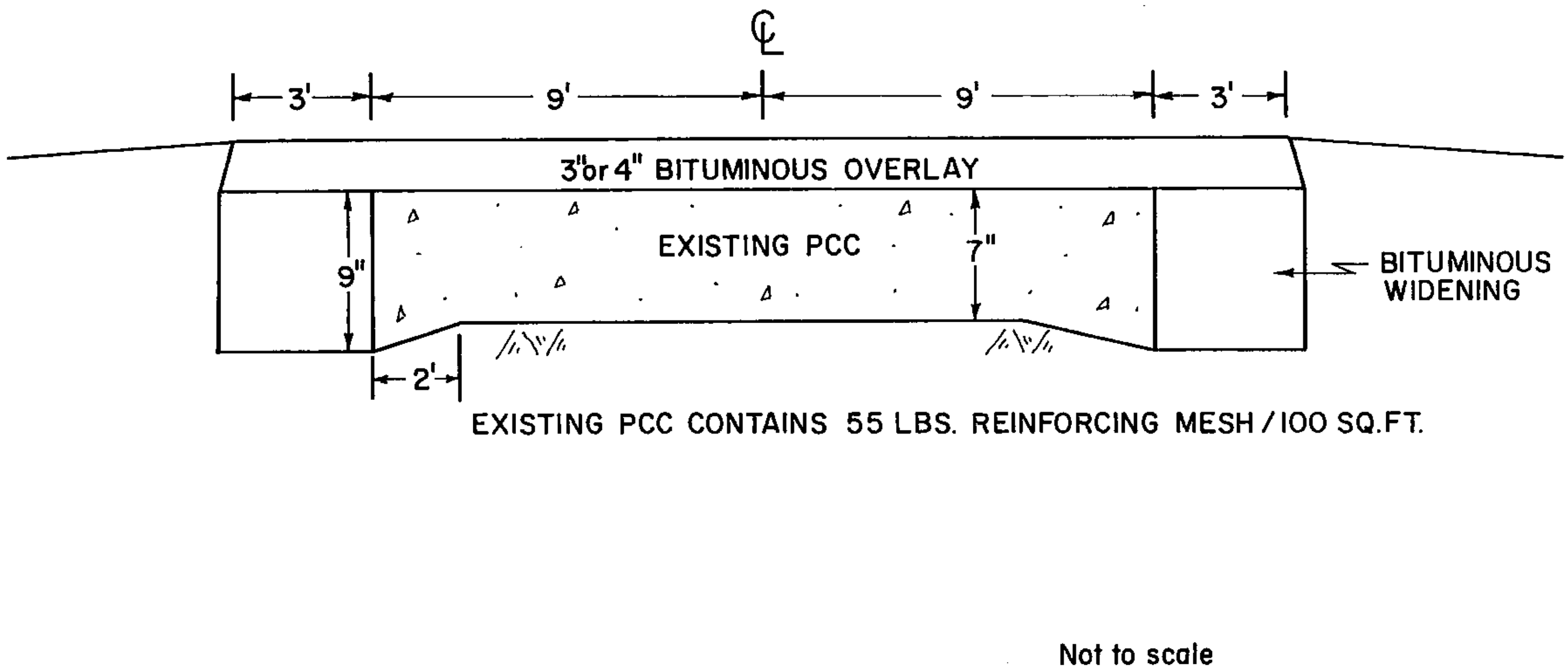
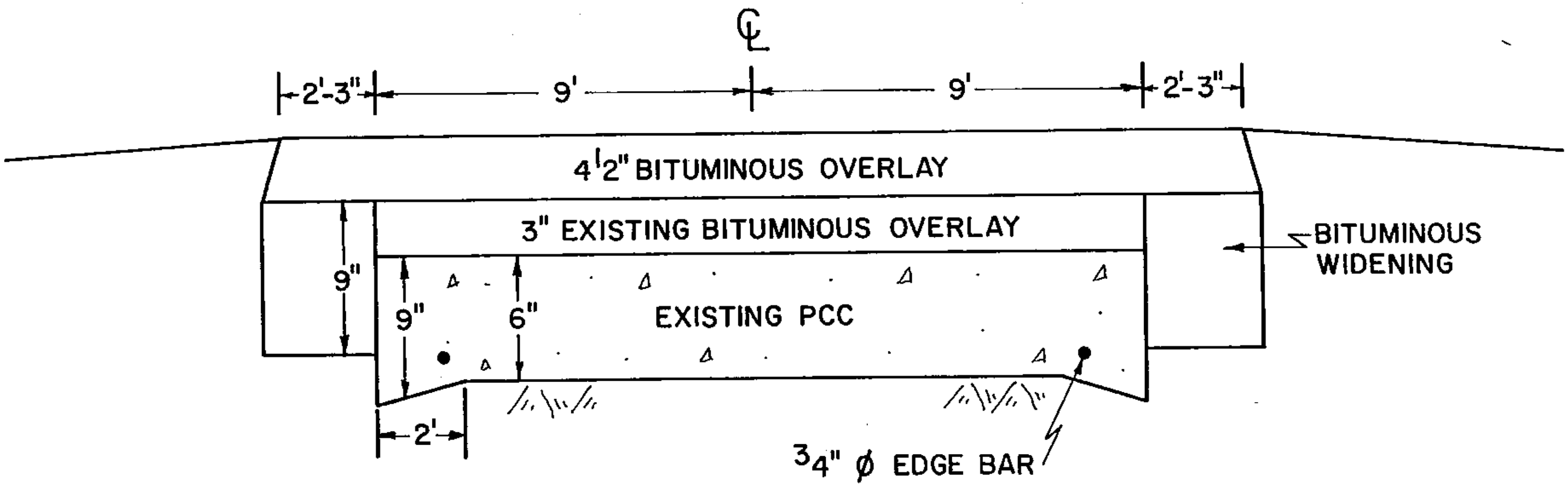
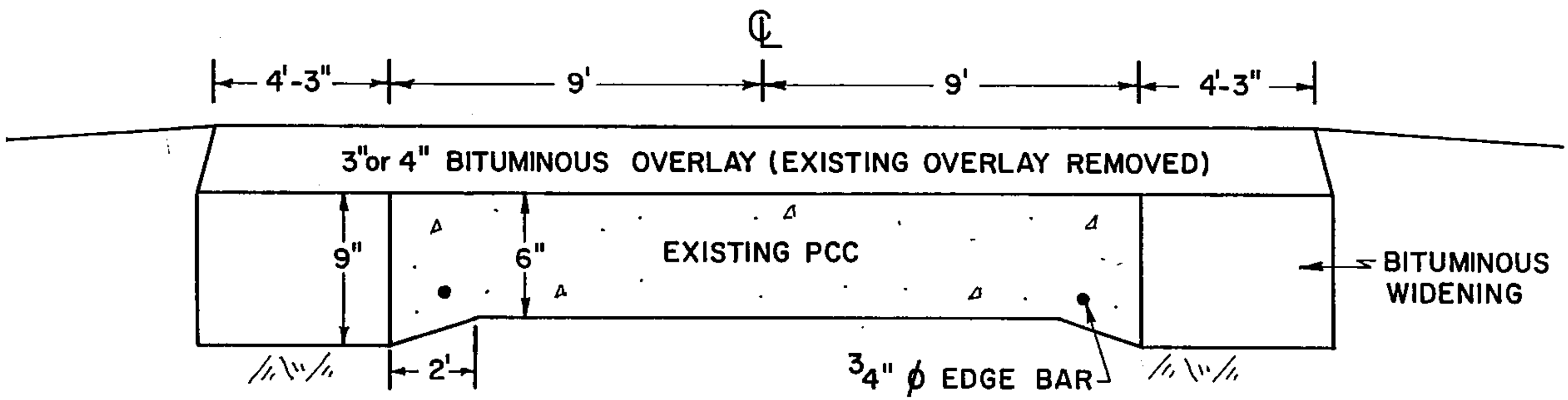


FIGURE 3: ILLINOIS ROUTE 97 CRACK AND SEAT CROSS SECTION



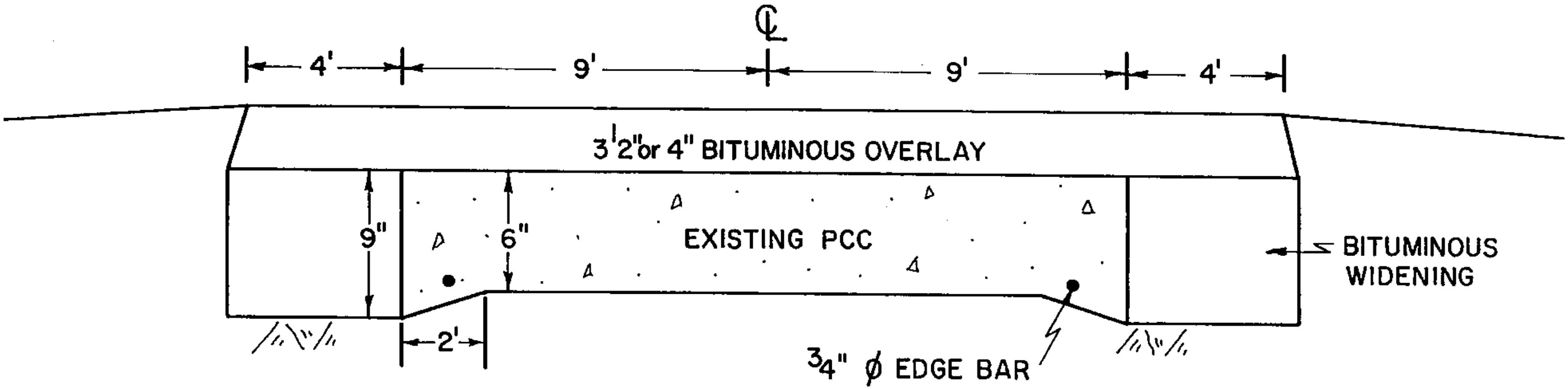
Not to scale

FIGURE 4: ILLINOIS ROUTE 101 CRACK AND SEAT CROSS SECTION



Not to scale

FIGURE 5: ROCKTON ROAD CRACK AND SEAT CROSS SECTION



Not to scale

FIGURE 6: U. S. ROUTE 6 CRACK AND SEAT CROSS SECTION

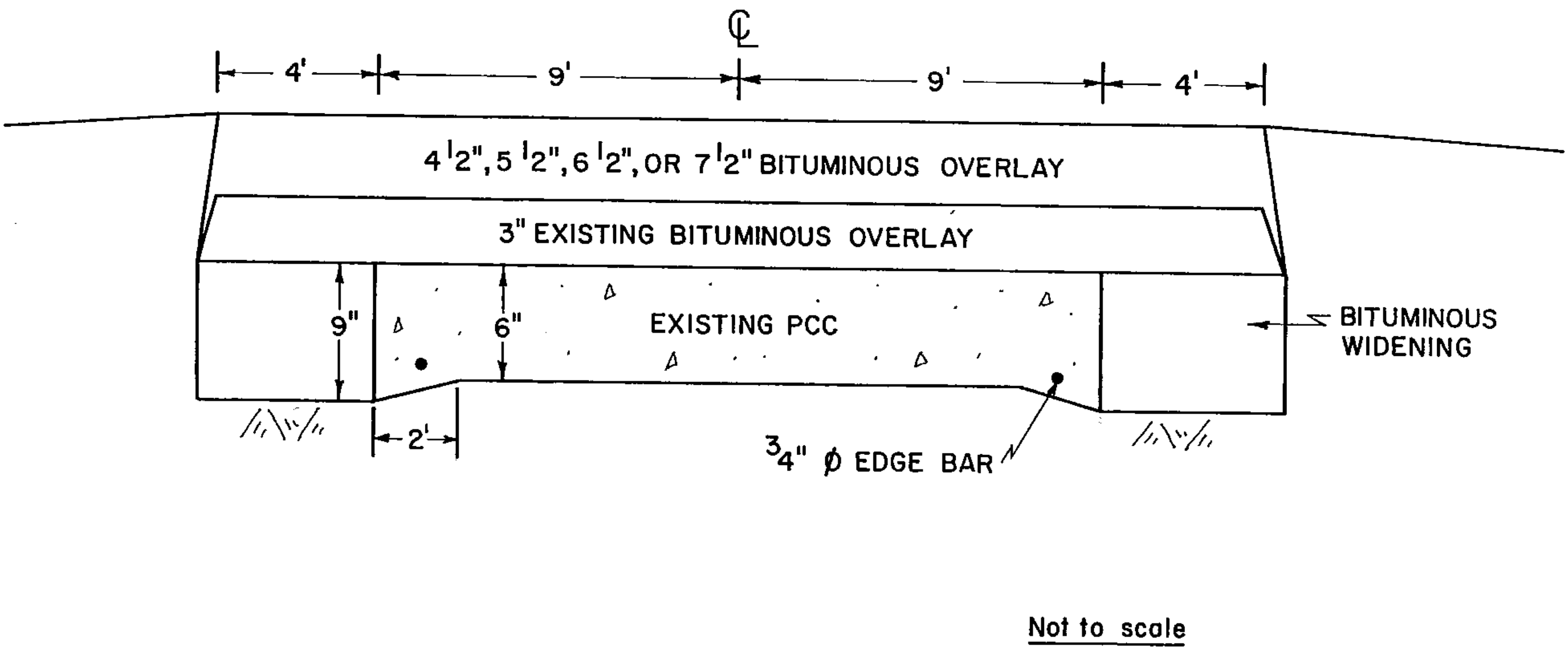


FIGURE 7: ILLINOIS ROUTE 99 CRACK AND SEAT CROSS SECTION

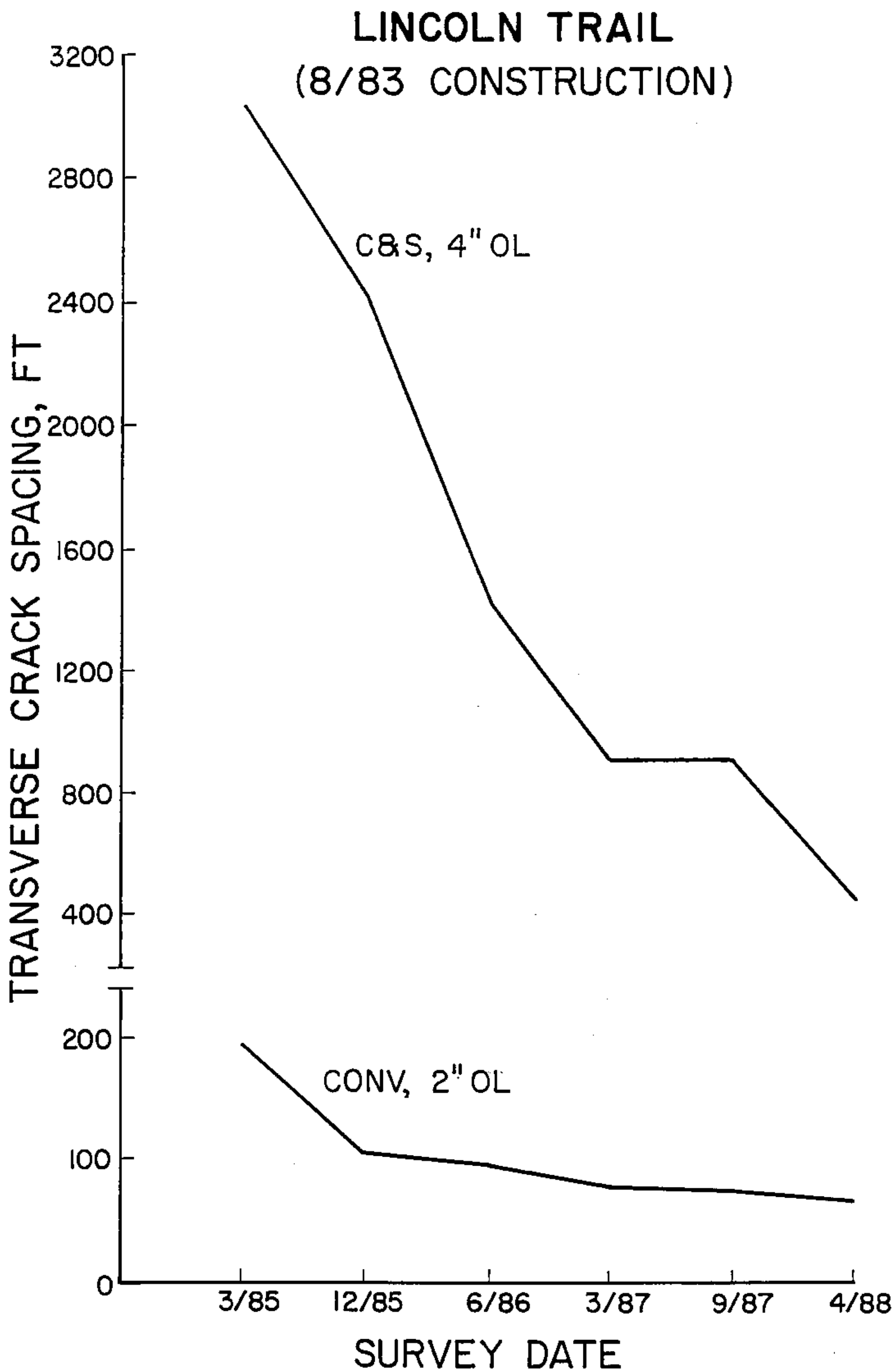


FIGURE 8: TRANSVERSE CRACK SPACING VS. TIME FOR LINCOLN TRAIL

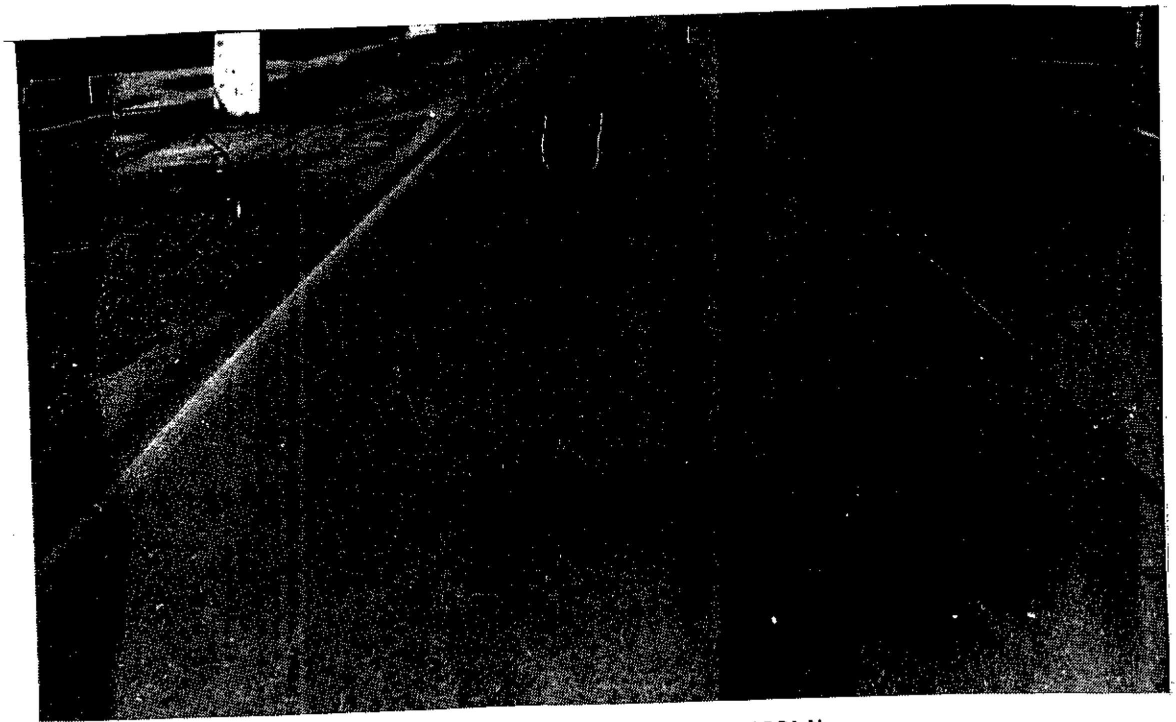


FIGURE 9: LONGITUDINAL CRACKING ON LINCOLN TRAIL CRACK AND SEAT SECTION

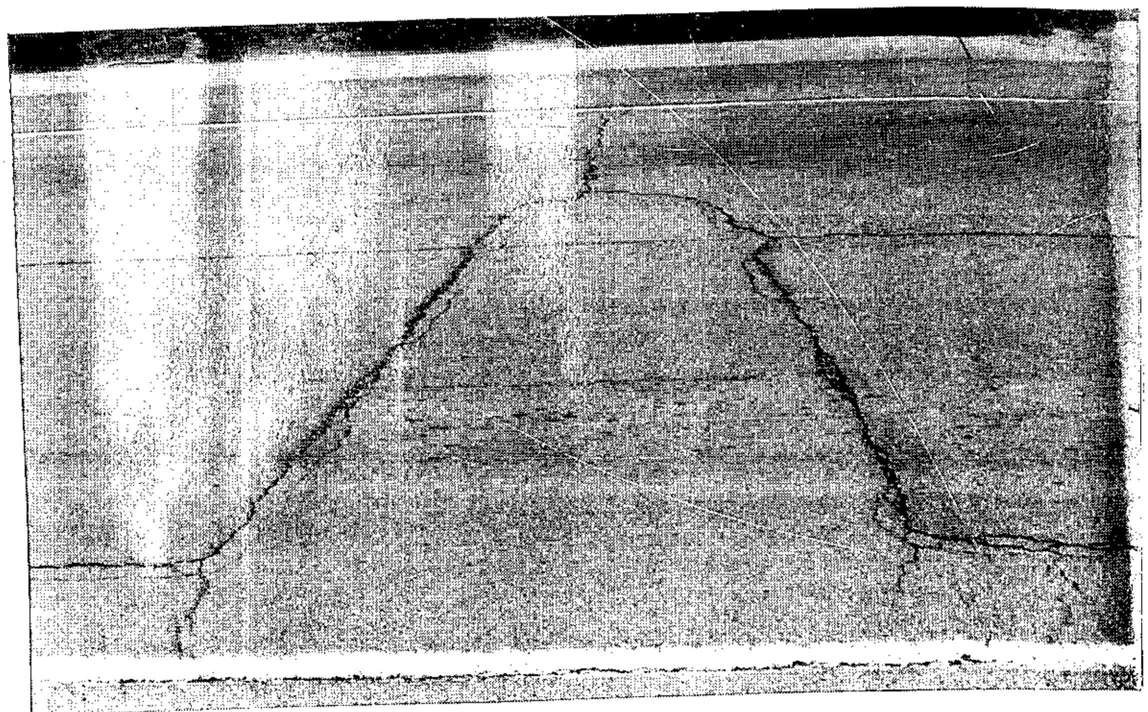


FIGURE 10: PATCH REFLECTED THROUGH 3-INCH CONTROL SECTION ON ILLINOIS ROUTE 97

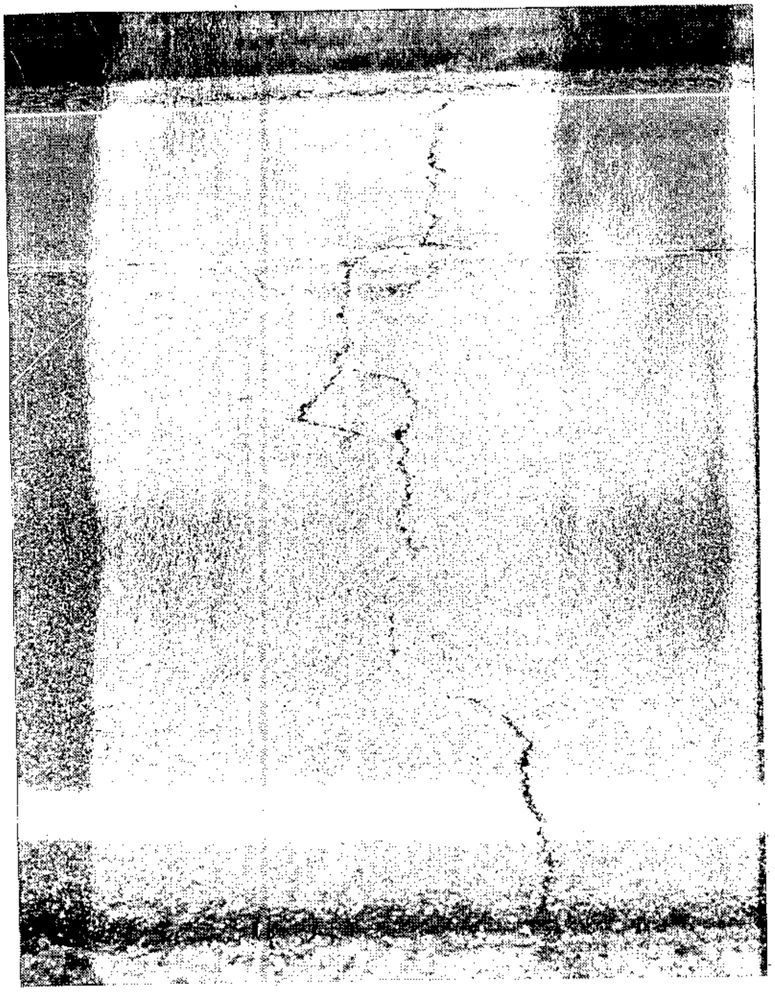


FIGURE 11: TRANSVERSE CRACKING IN 3-INCH CRACK AND SEAT SECTION ON ILLINOIS ROUTE 97

FIGURE 12: MID-LANE LONGITUDINAL CRACKING IN 4-INCH CRACK AND SEAT SECTION ON ILLINOIS ROUTE 97

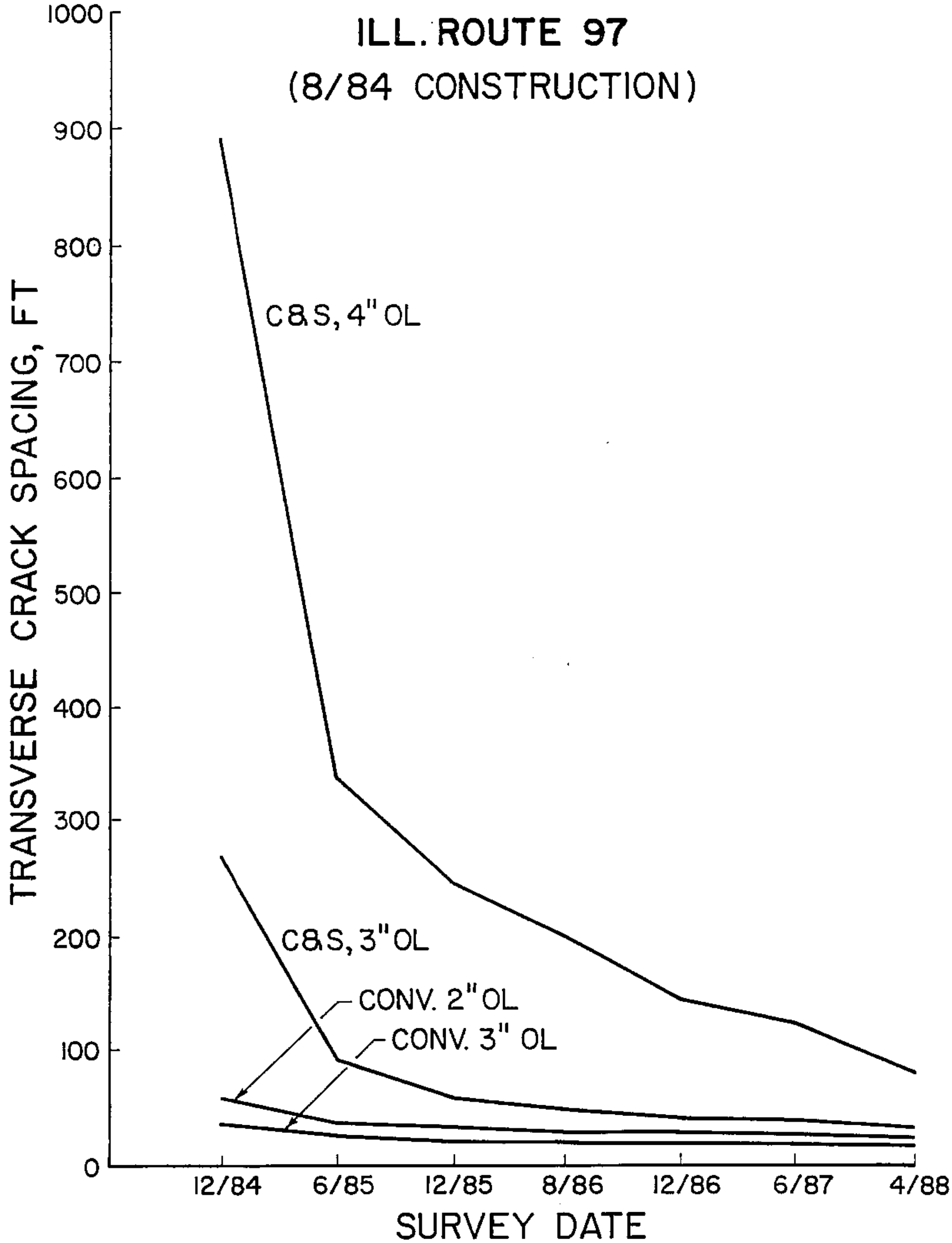


FIGURE 13: TRANSVERSE CRACK SPACING VS. TIME FOR ILLINOIS ROUTE 97

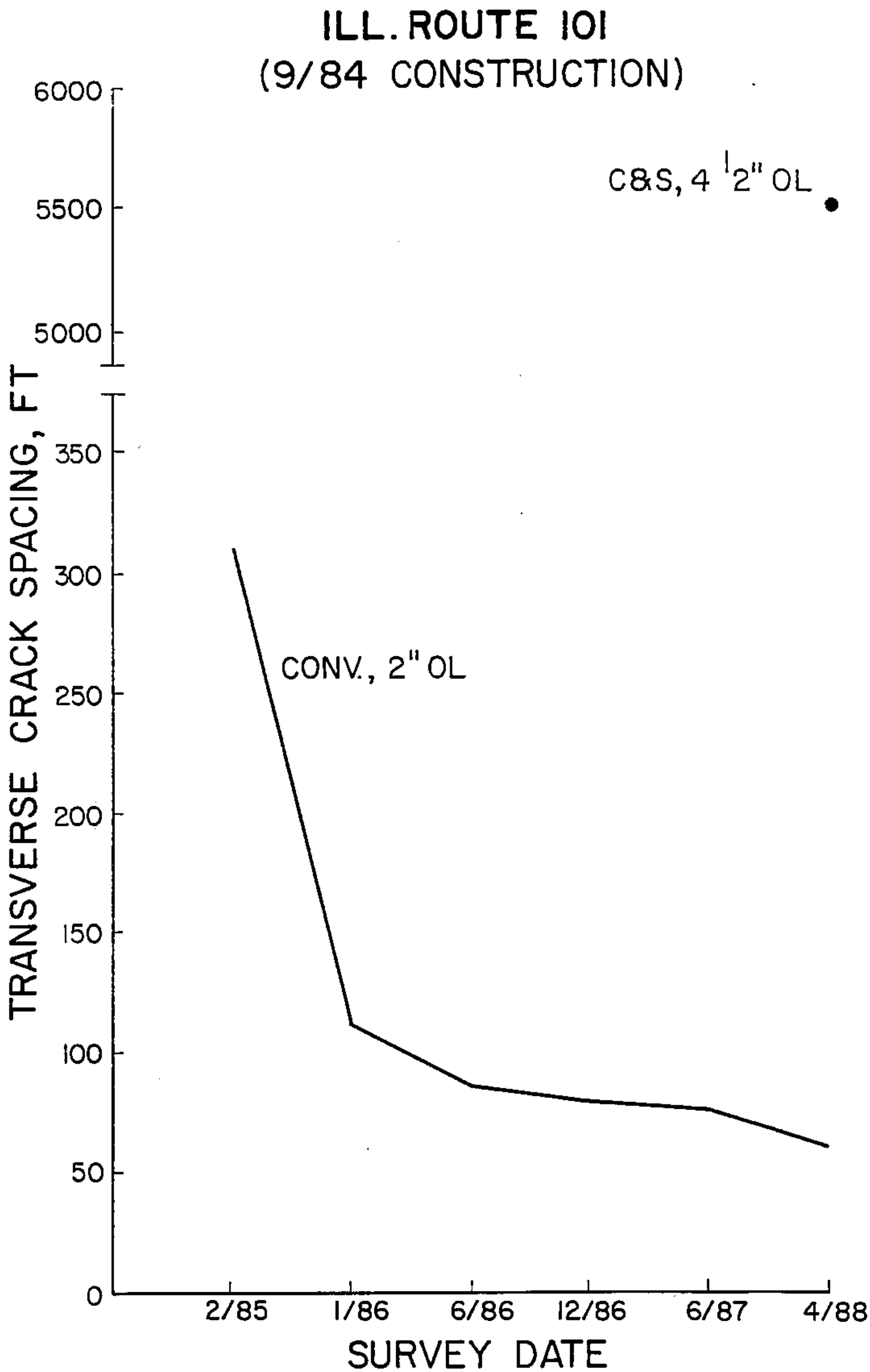


FIGURE 14; TRANSVERSE CRACK SPACING VS. TIME FOR ILLINOIS ROUTE 101

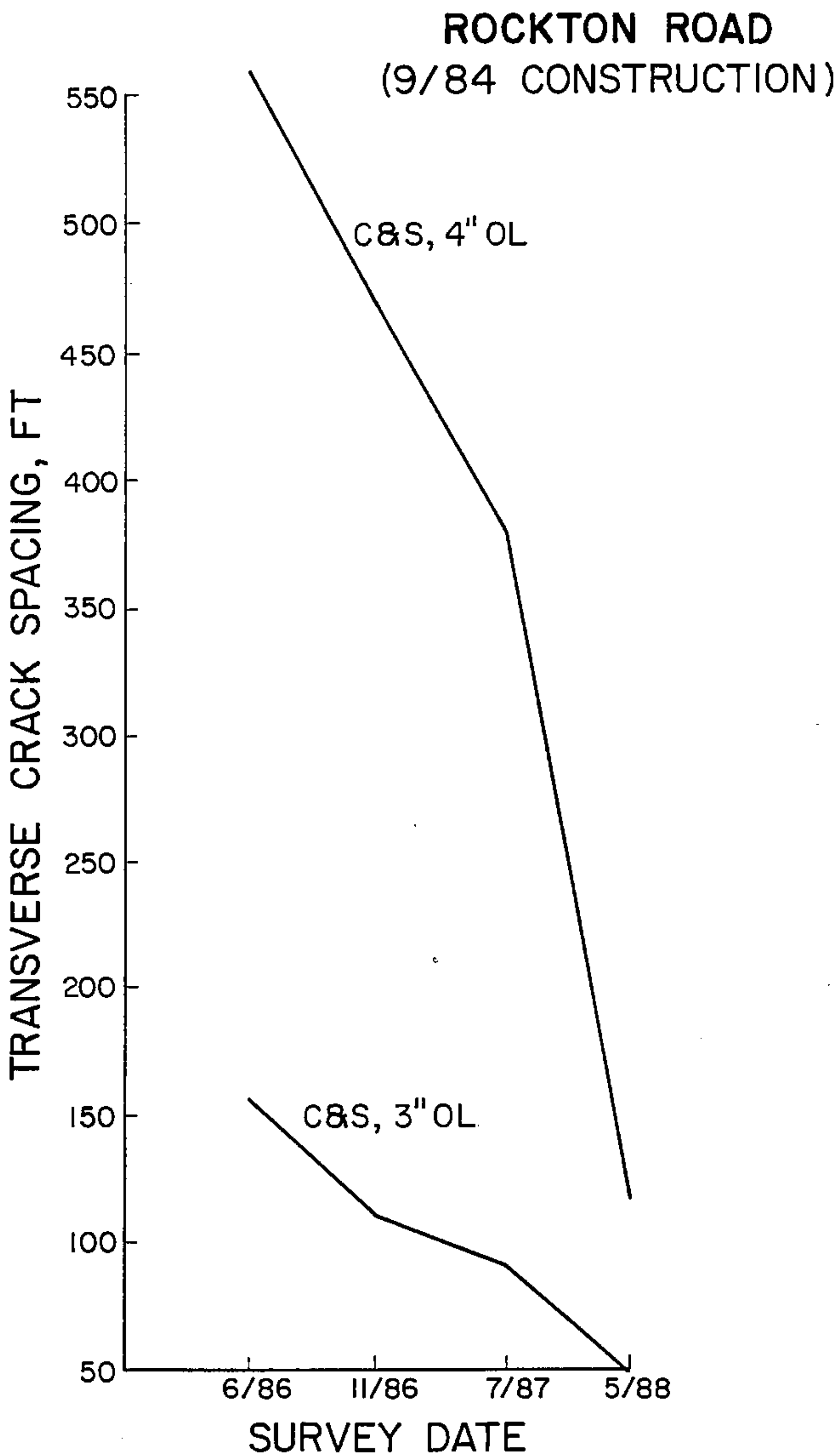


FIGURE 15: TRANSVERSE CRACK SPACING VS. TIME FOR ROCKTON ROAD

FIGURE 16:
REFLECTIVE CRACKING IN 4-INCH SECTION ON ROCKTON ROAD WITH HISTORY OF WATER PROBLEMS

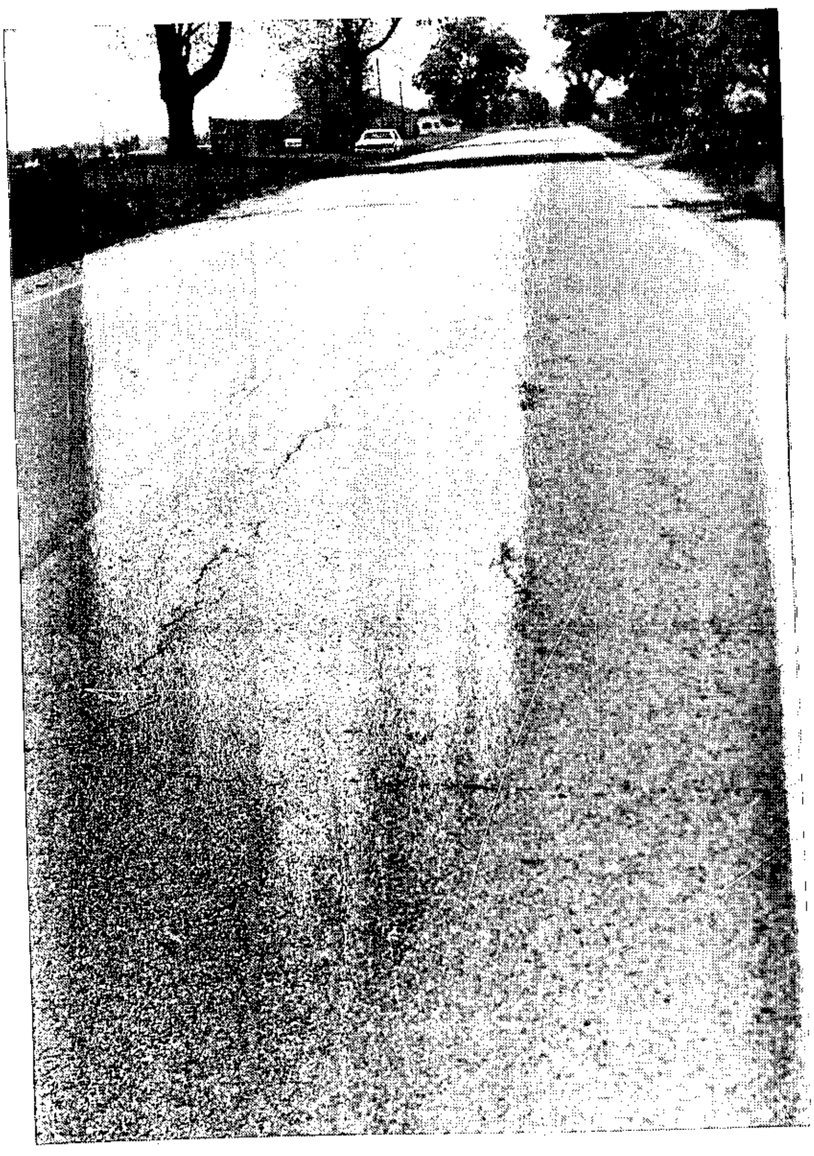


FIGURE 17: REFLECTIVE CRACKING AND SEGREGATION IN 3 1/2-INCH CRACK AND SEAT SECTION ON U. S. ROUTE 6

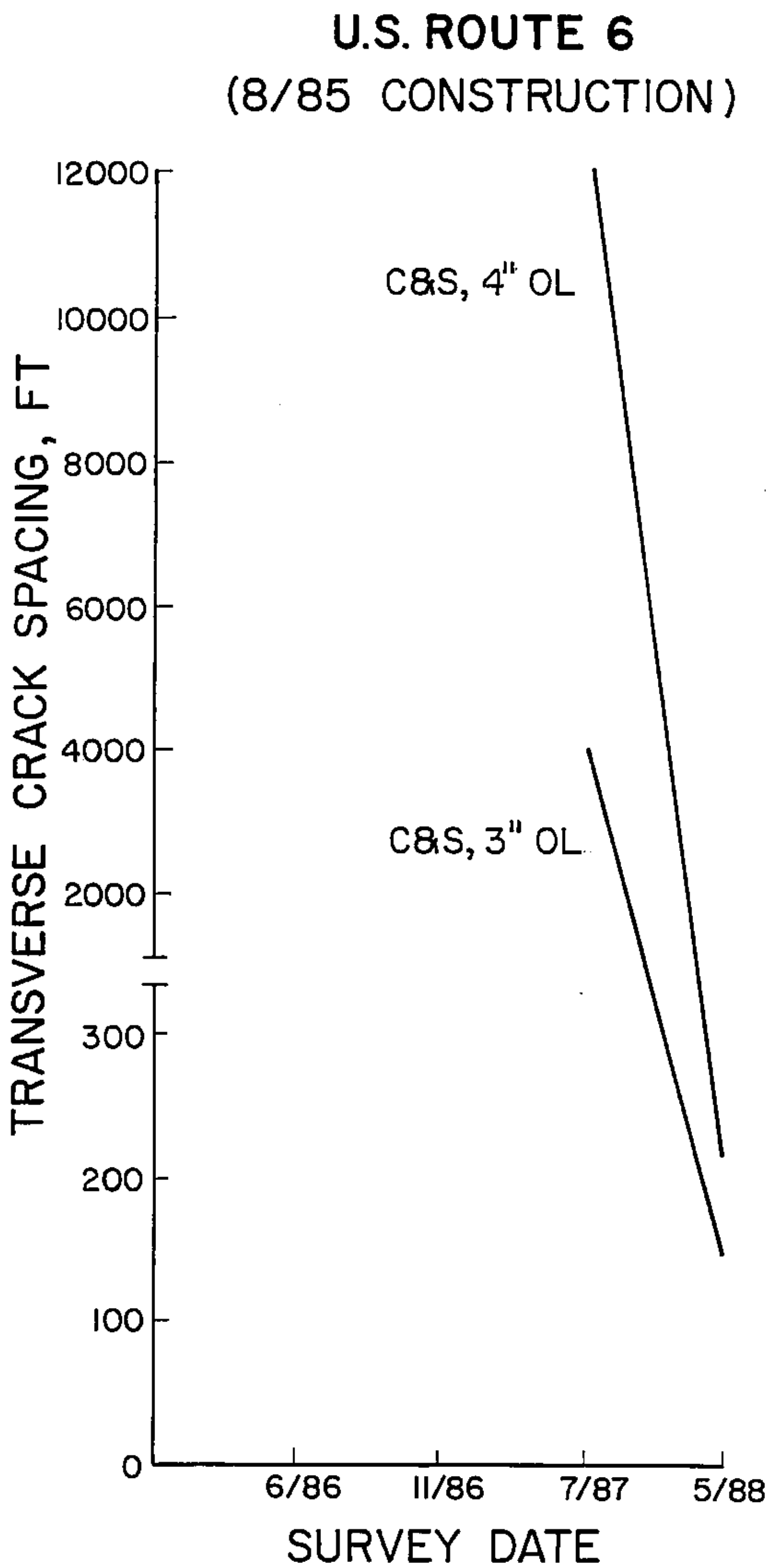


FIGURE 18: TRANSVERSE CRACK SPACING VS. TIME FOR U. S. ROUTE 6

APPENDIX A

SAMPLE SPECIFICATION

PAVEMENT CRACKING AND SEATING: This work shall consist of furnishing all equipment and labor necessary to crack and seat the existing pavement at those locations shown on the plans and as described herein.

The existing portland cement concrete pavement shall be cracked into 1 1/2 feet to 2 feet pieces in place using equipment approved by the Engineer. The equipment shall be capable of delivering sufficient dynamic force to crack the pavement full-depth. However, the cracking is not to be destructive. The cracks shall be fine lines between the individual pieces with aggregate interlock maintained.

The pavement breaker shall incorporate a guided free-falling drop weight of no less than 12,000 pounds and between 5 1/2 and 6 1/2 feet wide. The pavement breaker shall be capable of producing full-lane width transverse cracking. Unguided free-falling weights such as headache or wrecking balls will not be allowed.

Cracking will not be permitted over drainage facilities, and shall be stopped 2 feet either side of the drainage facilities. The Engineer will mark the limits in these areas prior to cracking the pavement.

Before cracking operations begin, the Engineer will designate test sections. The Contractor shall crack the test sections using varying energy and striking patterns, as designated by the Engineer, until a pattern is established that will crack the pavement to the extent required. In order to substantiate that the pavement cracking equipment is operating properly, the

Contractor shall remove 50-foot strips of bituminous concrete, as described in this proposal under BITUMINOUS CONCRETE REMOVAL, so that the underlying concrete may be inspected. The pattern thus established shall be used to crack the pavement on the remainder of the project. When cracking the test sections, the Contractor shall furnish and apply a light spray of water to dampen the pavement surface after cracking so the extent of cracking can be readily determined.

The cracked pavement shall be rolled with a 35-ton pneumatic tire proof roller to ensure that all pieces of cracked pavement are firmly seated against the subgrade. The roller shall meet the requirements as specified in Article 801.01b of the Standard Specifications. The rolling pattern is to be determined by the Engineer such that the passes overlap to ensure full coverage. Not more than five (5) one-way passes will be allowed per lane.

If traffic is allowed on the cracked pavement prior to seating, or on the cracked and seated pavement prior to placement of the first bituminous course, the Contractor shall maintain the pavement for traffic to the satisfaction of the Engineer. If the cracked and seated pavement is open to traffic for a long period of time prior to overlaying, the pavement shall be rolled immediately prior to overlaying to the satisfaction of the Engineer.

The Contractor shall exercise caution during all phases of construction to prevent damage to culverts. Crawl speed shall be maintained while crossing culverts or moving to position. No excessive turning movements will be allowed on the culverts and only one piece of construction equipment is to be allowed on culverts at one time.

Any soft areas that are observed during and after the rolling shall be removed and patched full-depth.

The removal and replacement of soft areas as described herein will be paid for at the contract unit price per square yard for PAVEMENT REMOVAL AND BITUMINOUS REPLACEMENT 9", of the type specified. After patching, the pavement shall be swept clean of debris prior to priming and the placement of the first lift of bituminous concrete binder course.

The proposed widening shall be constructed prior to cracking and seating the pavement. The new and existing bituminous widening shall not be cracked or seated. Every precaution shall be taken by the Contractor to avoid any damage or displacement of the widening during the cracking and seating operation.

The accepted quantities of cracking and seating concrete pavement will be paid for at the contract unit price per square yard for PAVEMENT CRACKING AND SEATING and will be considered full compensation for furnishing all labor, equipment and incidentals necessary to acceptably crack and seat the existing portland cement concrete pavement, including furnishing and applying water as specified to determine the extent of cracking.

<u>BITUMINOUS CONCRETE REMOVAL</u>: This work shall consist of the removal and disposal of portions of the existing bituminous concrete, during the cracking and seating operation, to ascertain that the pavement is being properly cracked. The Contractor shall periodically remove and inspect 50-foot portions of the bituminous concrete. If the pavement cracking equipment is not providing the desired results, additional 50-foot strips shall be removed and inspected to the satisfaction of the Engineer.

This work shall be paid for at the contract unit price per square yard for BITUMINOUS CONCRETE REMOVAL, which price shall include the disposal of the bituminous concrete. Replacement of the bituminous concrete shall be performed in accordance with Section 406.06 of the Standard Specifications and shall be paid for at the contract unit price per ton for LEVELING BINDER (MACHINE METHOD).

FIGURE 9: LONGITUDINAL CRACKING ON LINCOLN
TRAIL CRACK AND SEAT SECTION

FIGURE 10: PATCH REFLECTED THROUGH 3-INCH CONTROL
SECTION ON ILLINOIS ROUTE 97

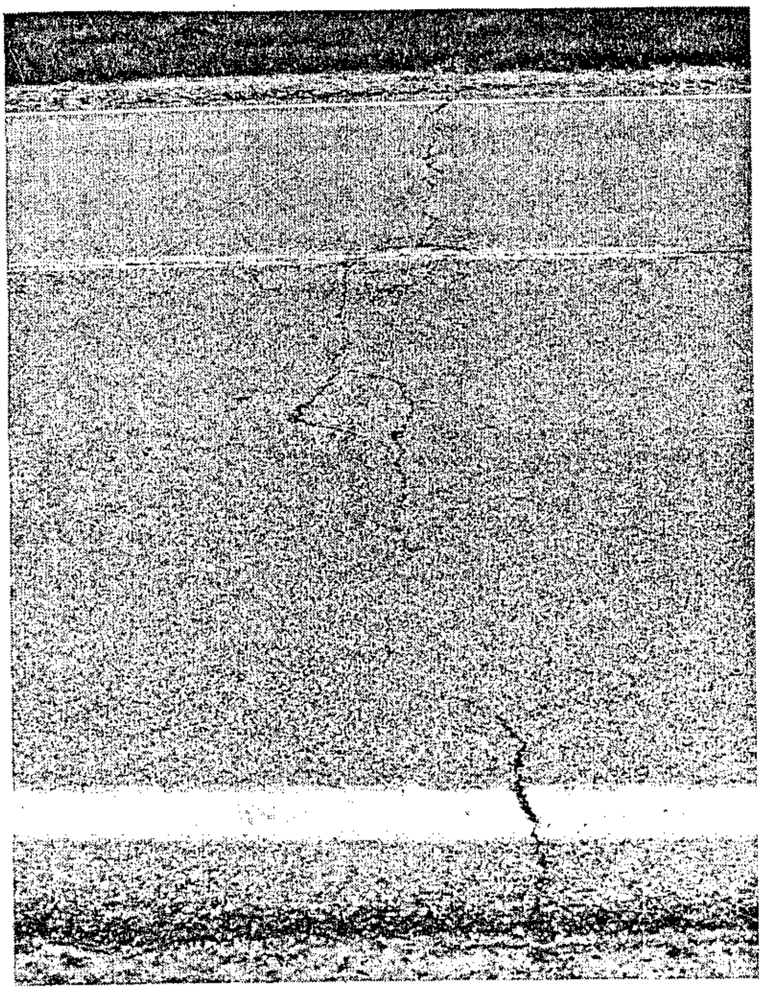


FIGURE 11: TRANSVERSE CRACKING IN 3-INCH CRACK AND SEAT SECTION ON ILLINOIS ROUTE 97

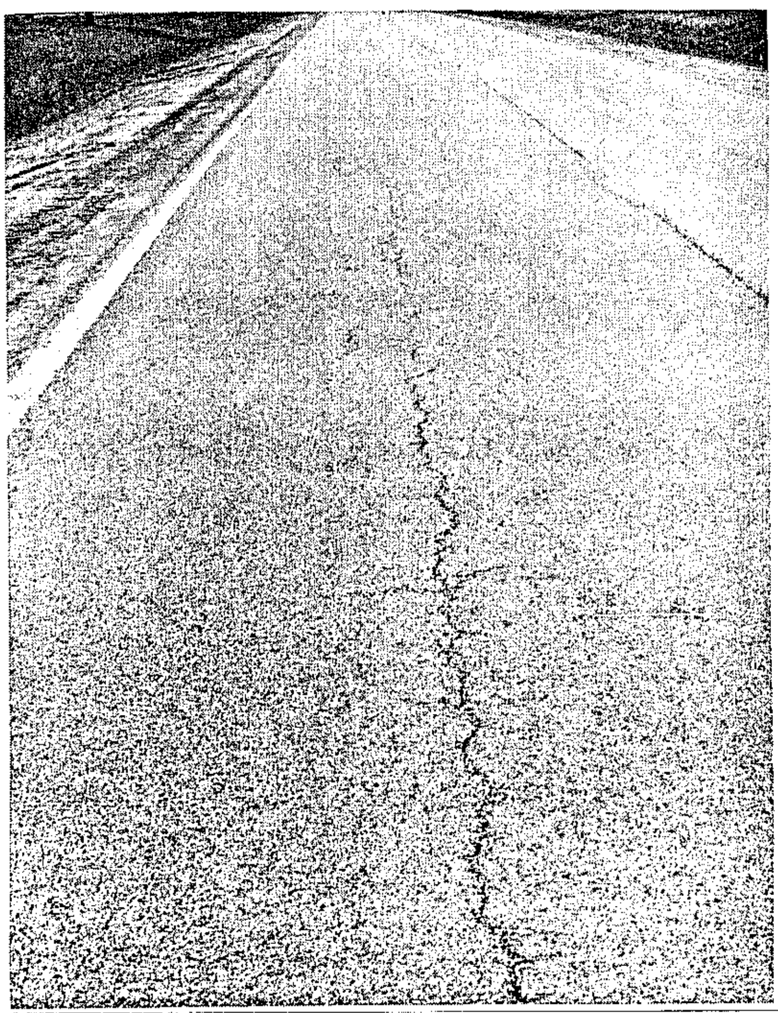


FIGURE 12: MID-LANE LONGITUDINAL CRACKING IN 4-INCH CRACK AND SEAT SECTION ON ILLINOIS ROUTE 97

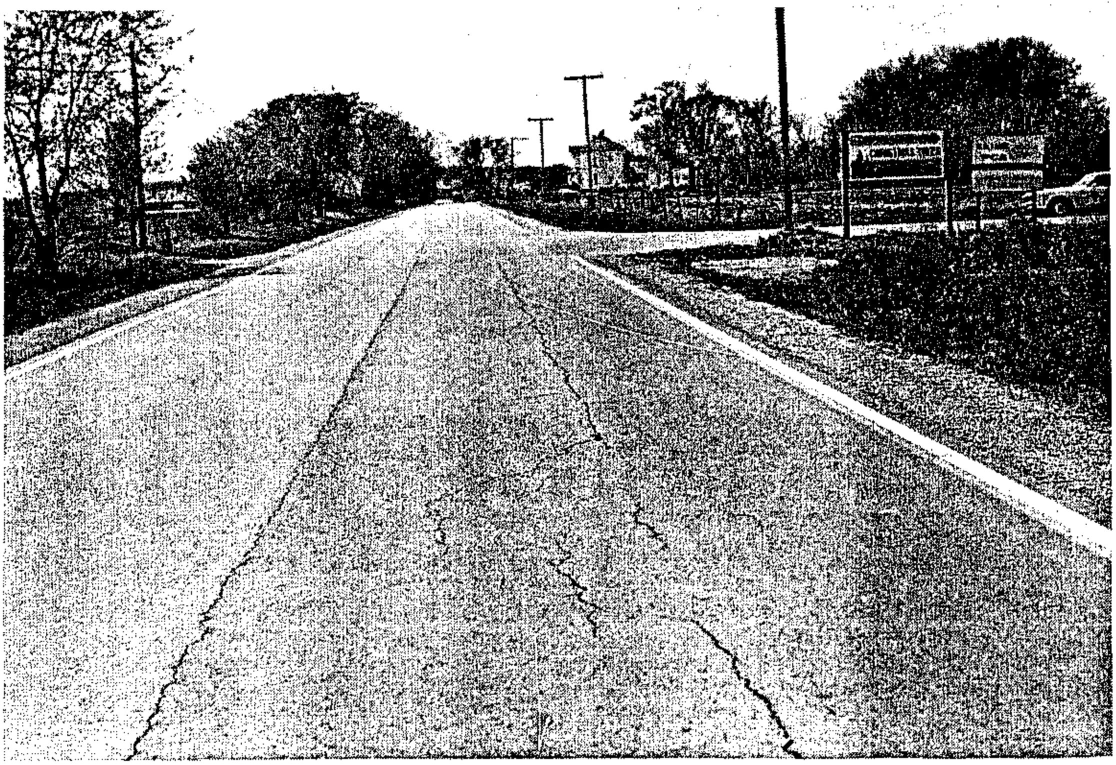


FIGURE 16:
REFLECTIVE CRACKING IN
4-INCH SECTION ON
ROCKTON ROAD WITH
HISTORY OF WATER
PROBLEMS

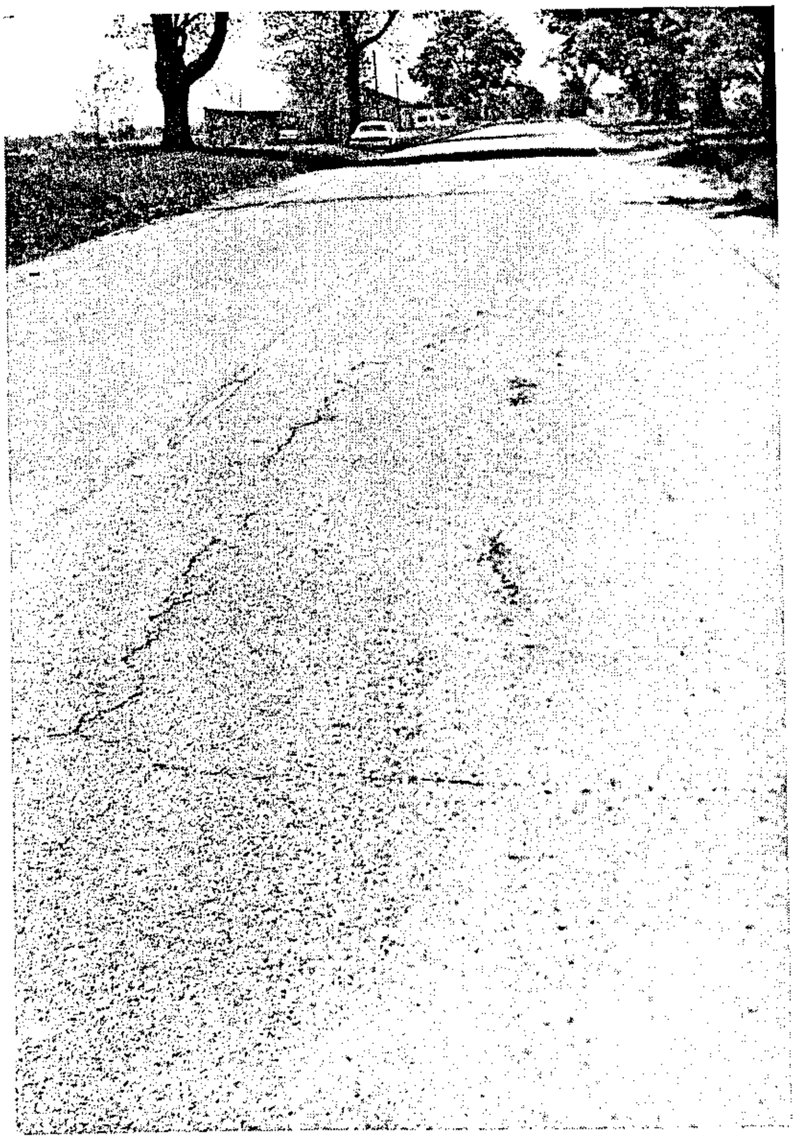


FIGURE 17: REFLECTIVE CRACKING
AND SEGREGATION IN 3 1/2-INCH
CRACK AND SEAT SECTION ON
U. S. ROUTE 6